NATIONAL WEATHER SERVICE
OPERATIONS AND SERVICES IMPROVEMENT PROCESS

PROGRAM PLAN

Gridded Model Output Statistics (MOS) Guidance

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Revision History

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1. Introduction

1.1 Statement of Need

For years, NWS forecasters have used the Model Output Statistics (MOS) guidance as an aid in producing text forecast products that are issued to the user community. The MOS guidance provides an objective interpretation of the underlying numerical weather prediction (NWP) model in terms of the weather elements that the NWS forecaster must include in many of the daily products. This objective interpretation removes the systematic bias of the NWP model, provides probabilistic estimates for the occurrence of certain weather elements, calibrates the station-specific guidance to the observations, enhances the NWP model forecast by the use of additional forecast variables, and tends toward mean conditions as uncertainty in the model solution increases. Use of the MOS approach requires an historical sample of observations and coincident NWP model forecasts. Most frequently, the MOS guidance is valid for specific observing sites, and the vast majority of the current MOS guidance is issued in text or binary format for specific sites. The use of remote sensing data as a source of observations allows this approach to be modified, since the remote sensing data, being random in space and time, are usually projected onto a grid of regularly spaced points for a specific interval of time. With this approach, MOS guidance (for example, the probability of thunderstorms) is valid for a grid of some pre-specified resolution.

As part of the NWS modernization, the methods that the forecasters use to generate the standard forecast products have changed. In addition, the products themselves have been modified, and new products have been added to the daily workload. To facilitate the forecast process, the forecasters use the Interactive Forecast Preparation System (IFPS) to prepare a digital database of gridded data from which official and experimental products are generated. The IFPS Graphical Forecast Editor (GFE) provides the forecasters with tools to edit grids and thus to prepare the gridded forecast database. Algorithms within IFPS project the MOS guidance onto a grid, and this gridded rendition of the MOS guidance provides the forecasters with a first guess for the digital database. However, this grid lacks the spatial resolution needed by the NWS forecasters. Consequently, the forecasters are not able to use the MOS guidance effectively and so must spend time manipulating direct model output grids or introducing detail into the MOS grids. In either case, the forecasters are hindered in their mission to provide an accurate, timely digital database to NWS customers and partners.

MDL is proposing to correct this deficiency by generating and disseminating MOS guidance on grids with the resolution of the National Digital Forecast Database (NDFD), currently set at 5 km over the CONUS. The project objective is to produce the MOS guidance on a high-resolution grid (spacing of 2.5 to 5 km between grid points) with a level of accuracy comparable to that of the station-oriented MOS guidance. The initial implementation of gridded MOS products will focus on grids for the CONUS, with grids for Alaska to follow approximately 1 year later. Grids for Hawaii and the western Pacific will follow in subsequent years as the methodology for producing the grids matures.

1.2 Objectives

The objectives of the program is to produce MOS guidance on a high-resolution grid, initially with a spacing of 5 km between grid points, with a level of accuracy comparable to that of the station-oriented MOS guidance. The guidance is to be created at the NOAA Central Computing System (NCCS), packed into GRIB2 format, and transmitted on the SBN to the local WFO's. At the WFO's, the data are to be decoded and stored in NetCDF files for possible use by the forecasters in producing local forecast grids. The data are also to be made available to the NCEP HPC for consideration in generating the HPC guidance grids.

While the initial grids will have a spacing of 5 km between grid points, nothing in the techniques being developed will preclude going to a higher resolution grid, for example, with a spacing of 2.5 km between grid points. The initial development of the MOS grids is focused on the contiguous United States (CONUS). Grids for Alaska, Hawaii, Puerto Rico, and the western Pacific Islands will follow later as the technology matures. The plans are to prepare the Alaska grids within a year or two of the initial deployment of the CONUS grids.

Initial plans are to produce guidance grids for maximum and minimum (max/min) temperature, 2-m temperature, 2-m dew point, 2-m relative humidity, wind direction, wind speed, probability of precipitation, precipitation amount and type, probability of thunderstorms, sky cover, and snowfall amount. These grids will be made available twice daily, from the 0000 and 1200 UTC runs of the Global Forecast System (GFS) model, and will provide guidance out to 7 days in advance for many of the elements.

1.3 Relation to NOAA/NWS Strategic Plan

The work described in this program plan is designed to support two objectives in the NOAA strategic plan (see http://www.spo.noaa.gov/). In particular, MOS guidance provided to the forecasters will help to increase the lead time and accuracy for weather and water warnings and forecasts, as well as assist in reducing weather related transportation crashes and delays. In the NWS strategic plan (see http://www.nws.noaa.gov/sp/), statistical forecast models such as MOS are required to "improve the reliability, lead-time, and understanding of weather and water information and services." Efforts such as the development, implementation, and dissemination of MOS grids will also serve to "develop and infuse research results and new technologies more efficiently to improve products and services, to streamline dissemination, and to communicate vital information more effectively. Finally, guidance provided by the high-resolution MOS grids should help to "increase the capabilities, efficiencies, and accuracy of transportation-related products and services" and "support decisions on aviation, marine, and surface navigation efficiencies."

1.4 Relation to NOAA Mission Goals

The scientific research, development, and analysis required to support the Gridded MOS guidance is done within the Statistical Modeling Branch, Meteorological Development Laboratory, OST. The MOS development is part of the NOAA mission goal team for Weather and Water, and is located within the Environmental Modeling Program.

2. Research

2.a Description

The MOS approach is a well-documented, frequently-used approach for the objective interpretation of numerical weather prediction (NWP) model output. For over 30 years, NWS forecasters have had access to MOS guidance based on the output of a succession of NWP models run within the NWS. In general, the forecasters could choose to use or ignore the guidance. A number of verification studies have shown that the forecasters improved upon the MOS guidance for certain weather elements, particularly in highly unusual weather events. For many weather elements, both the human forecaster and the MOS guidance had comparable levels of skill. In almost all cases, with the exception of thunderstorm probabilities, the MOS guidance was valid for specific observing sites, and the essence of the MOS approach was to correlate observations at specific sites with model forecasts interpolated to those sites. The requirement for guidance on a 5-km grid, however, challenges the normal MOS approach since observations are normally unavailable at such a high spatial resolution. The research done for this program will determine if the MOS approach or an adaptation of it can produce guidance grids with the detail and accuracy that the forecaster needs to more efficiently initialize the local digital database. The objective of the research and development is to produce gridded MOS guidance with accuracy comparable to that of the station-oriented guidance. Observations from both mesonet systems and remote-sensing platforms will be incorporated into the MOS system, and a sophisticated analysis system will be developed to blend the station-specific information with high-resolution geophysical data to create guidance grids. The work will be done by staff of the Statistical Modeling Branch of MDL/OST. Necessary software development will be done in Silver Spring or via remote access to the NCCS.

2.b Roles and Responsibilities

Members of the Statistical Modeling Branch of MDL/OST (W/OST22) are responsible for research and the necessary software to do that research. Members of the Interactive Forecast Preparation System Science Steering Team (ISST) are available for informal consultation.

2.c Work and Budget Breakdown

The fully-staffed Statistical Modeling Branch contains 11 full-time equivalent federal employees, and 1 contractor. Costs for the Branch are approximately $1.1 million annually, and are obtained via the NOAA planning, programming, and budget execution process.

Work tasks include the following:

- Acquisition, quality control, and preparation of observational datasets
- Preparation of required model output datasets
- Development of appropriate MOS forecast test equations
- Testing and evaluation of forecasts from test equations
- Redevelopment of MOS operational equations
- Implementation of MOS operational equations in the NCCS parallel system
- Preparation of appropriate post-processing software
- Coordination with NCEP/TOC for dissemination of guidance products
- Evaluation by ISST or other NWS forecasters of gridded guidance
- Modification of process used to create gridded guidance
- Reimplementation of enhanced process used to generate guidance

These tasks may be required multiple times, according to the geographical area covered by the grids, as well as the weather elements for which the guidance is valid.

2.d Acquisition Strategy

Budget resources are obtained via the normal NOAA budgeting process. The Statistical Modeling Branch is funded through the NOAA Weather and Water Goal Team, Environmental Modeling Program. The contractor employee is hired through the NWS task order contract with RSIS.

2.e Performance Measures and Success Criteria

Standard verification procedures will be used to evaluate objectively the quality of the gridded products. In particular, the values from selected grids will be interpolated to specific observing sites and then will be compared to both the station-specific MOS guidance at that point as well as the operational NDFD forecast. While the gridded MOS guidance will be less accurate when this process is done than the station-specific MOS guidance, both sets of MOS guidance should be of approximately the same accuracy as the NDFD guidance. A subjective evaluation of grid quality and usefulness will be carried out by members of the ISST, HPC forecasters, and WFO forecasters.

Success for this effort will be established by the accuracy measures as well as by the subjective evaluation of the representatives of the user community.

2.f Schedules and Milestones

March 31, 2005 – Create prototype gridded products for western U.S. containing temperature and dew point guidance
September 30, 2005 – Obtain mesonet data for U.S. to be used in MOS development
December 31, 2005 – Develop and test experimental temperature, dew point, wind direction, wind speed, cloud, and probability of precipitation forecast equations for CONUS
March 31, 2006 – Develop operational temperature, dew point, wind direction, wind speed, cloud, and PoP forecast equations for CONUS
June 30, 2006 – Complete processing of high-resolution precipitation estimates for use in developmental system
August 31, 2006 – Develop and test experimental precipitation type forecast equations
September 30, 2006 – Develop operational precipitation type forecast equations for CONUS

2.g Assumptions and Constraints

The assumption is that adequate resources, namely staff and computer resources, are available to do this work. Computer resources include resources available through the NCCS, local personal computers, and ARCINFO software.

2.h Risk Assessment and Mitigation

The MOS approach itself is a highly developed technique that has been shown to produce good guidance at observation sites. The development of MOS is a very low risk process. However, the application of MOS at mesonet sites or by using remote-sensing data is somewhat more problematical because of the quality of the observational data. MDL, however, did a risk-reduction effort by ingesting mesowest data and creating the gridded prototype products. MDL also has some experience with using remote-sensing data in development of thunderstorm probability equations. Thus, MDL recognizes the need for extensive quality control of these new datasets. This is also a time-consuming task; additional human resources and appropriate GIS techniques will be applied to mitigate the risk of schedule overruns.

The greatest risk is associated with the scientific problem of putting the MOS guidance on a high-resolution grid with realistic detail between observing sites. This problem will be solved in incremental steps. Repeated verification and evaluation by the users will indicate problems. MDL plans to do periodic updates to improve the quality of the guidance products.

3. Analysis

3.a Description

Successful implementation of the gridded MOS products requires that extensive analyses be completed to evaluate both the accuracy of the gridded guidance and its usefulness to the NWS forecasters. In addition, the impact of generating the guidance in terms of computer resources and timeliness must be assessed from the perspective of the NCCS. Transmission of the high-resolution grids on the SBN will require that the size of the GRIB2 product files be estimated. When the products reach individual WFO's, they must be decoded, stored in the appropriate netCDF file, and made available to the forecaster for use in the Graphical Forecast Editor (GFE) and for viewing via the volume browser. Appendix A contains a preliminary list of gridded MOS products which will eventually be produced. Appendix B contains the list of WMO headers. Appendix C contains the file structure established on the Telecommunications Gateway ftp server for containing the gridded products.

3.b Roles and Responsibilities

Members of the Statistical Modeling Branch of MDL/OST (W/OST22) are responsible for evaluating the accuracy of the grids. Members of the Interactive Forecast Preparation System Science Steering Team (ISST), forecasters designated by NWS Regional Headquarters, and/or forecasters from HPC will assist in the subjective evaluation of the grids. Statistical Modeling Branch employees together with NCEP's Computer Operations (NCO) Division will assess the impact of gridded MOS on the NCCS. The Data Review Group and the Telecommunications Operations Center/OCIO are responsible for assigning WMO headers and measuring the impact of the MOS grids on the SBN. Members of SEC will be responsible for assessing the impact on AWIPS.

3.c Work and Budget Breakdown

Work tasks include the following:

- Verify a sample of each grid type; summarize grid accuracy
- Establish an instrument for a field forecaster evaluation of the grids
- Provide a subjective evaluation of the grids
- Implement the process that generates the gridded MOS products in the NCEP parallel jobstream; assess computer resources used
- Prepare and submit a Request for Change form to the Data Review Group
- Obtain Data Review Group approval
- Coordinate with SEC on assessing impact on AWIPS
- Validate that the GRIB2 decoder can decode the gridded MOS products

3.d Acquisition Strategy

Not applicable; resources required for this analysis should be relatively small with the exception of those required to verify the gridded products. The Statistical Modeling Branch is funded through the NOAA Weather and Water Goal Team, Environmental Modeling Program. The contractor employee is hired through the NWS task order contract with RSIS. The initial approach is to assess resources required for implementation of CONUS grids. Implementation of grids for OCONUS areas will require subsequent analysis.

3.e Performance Measures and Success Criteria

Success for this effort will be measured by completing the Data Review Group process within a timely manner, by the establishment of accuracy measures provided by MDL's Statistical Modeling Branch and by the subjective evaluation completed by representatives of the user community.

3.f Schedules and Milestones

July 31, 2005 – Submit Request for Change to obtain CONUS headers

September 30, 2005 – Establish process with ISST for forecaster evaluation of grids
November 30, 2005 – Implement process to produce grids in NCEP parallel jobstream
March 31, 2006 – Provide verification statistics for MOS grids over CONUS.
December 31, 2006 – Submit Request for Change to obtain WMO headers for products over Alaska, Hawaii, and Puerto Rico

3.g Assumptions and Constraints

The assumption is that adequate resources, namely staff and computer support (computing cycles and disk storage), are available to do this work.

3.h Risk Assessment and Mitigation

Doing the required analyses is a low-risk activity, as this type of work is done repeatedly. Completing the activities in a timely fashion is a problem because of the lack of staff to do the work.

4. Operational Development

4.a Description

Once the research and analysis phases are completed, the operational development is straightforward, albeit intensive, particularly for MDL. The complete set of required equations for all weather elements must be developed; this set will be quite extensive. Software required for the operational implementation must be written and/or updated to handle the CONUS grids. The necessary control files and operational processes must be created for use at the NCCS. The AWIPS GRIB2 decoder must be updated, if deficiencies are discovered.

4.b Roles and Responsibilities

Members of the Statistical Modeling Branch of MDL/OST (W/OST22) are responsible for development of the operational equations, control files, software, and processes required to make the gridded MOS products on the NCCS. NCEP's NCO is responsible for maintaining the NCCS which is used by MDL as the developmental computer platform. NCO is also responsible for providing guidelines for the operational implementation. SEC is responsible for updating the AWIPS GRIB2 decoder.

4.c Work and Budget Breakdown

Tasks include:

Development of appropriate MOS max/min temperature, temperature, dewpoint, wind speed, wind direction, wind gust, probability of precipitation, precipitation amount, snowfall, sky cover, thunderstorm, and precipitation type forecast equations for the CONUS
Development of operational software required for post-processing the MOS guidance and producing the gridded products
Modification of AWIPS GRIB2 decoder, if necessary
Enhancement of initial probability of precipitation and precipitation amount equations by use of remote-sensing estimates of precipitation and high-resolution precipitation climatologies in the equation development
Development of appropriate MOS forecast equations for Alaska
Enhancement of initial sky cover forecast equations by use of remote-sensing estimates of sky cover in the equation development
Development of appropriate MOS forecast equations for Hawaii

4.d Acquisition Strategy

Budget resources are obtained via the normal NOAA budgeting process. The Statistical

Modeling Branch is funded through the NOAA Weather and Water Goal Team, Environmental Modeling Program. The contractor employee is hired through the NWS task order contract with RSIS. Resources required for NCO and SEC will need to be assigned according to NCO and SEC priorities.

4.e Performance Measures and Success Criteria

Success is measured by developing the appropriate equations needed to generate the MOS guidance with the necessary level of accuracy. Development must be done in a timely manner according to the prescribed schedules. Another criterion for success is creating the grids with realistic detail and in a timely manner on the NCCS platform.

4.f Schedules and Milestones

September 2005 – Development of appropriate probability of precipitation, precipitation amount, thunderstorm, and snowfall forecast equations for the CONUS
December 2005 – Development of maximum/minimum temperature, temperature, dew-point, and wind forecast equations for the CONUS
March 2006 – Development of sky cover forecast equations for the CONUS
June 2006 – Development of precipitation type forecast equations for the CONUS
January 2007 – Development of enhanced probability of precipitation and precipitation amount forecast equations for the CONUS
March 2007 – Development of appropriate probability of precipitation, precipitation amount, temperature, dewpoint, wind, sky cover, thunderstorm, precipitation type, and snowfall forecast equations for Alaska
September 2007 – Development of high-resolution sky cover forecast equations for the CONUS

4.g Assumptions and Constraints

The assumption is that adequate resources, namely staff and computer support (computing cycles and disk storage), are available to do this work. Without adequate human and computing resources, the development of the operational system will not be completed in a timely manner.

4.h Risk Assessment and Mitigation

In addition to the scientific risk of providing guidance with insufficient accuracy to be useful to the forecasters, we face a significant risk of not providing the operational gridded guidance in a timely manner. The amount of calculations required to support a gridded MOS system is quite large and exceeds anything that MDL has ever encountered. Since the development and implementation is being done at the NCCS, we may need to convert the MOS implementation software into an architecture that can do parallel processing, in lieu of the traditional serial processing. Only experimentation and analysis of the time required to produce the grids will answer the question. To mitigate the risk, some members of MDL will take training in programming on a massively parallel system.

5. Deployment, Maintenance, and Assessment

5.a Description

For successful deployment and use of gridded MOS by the forecasters, a number of tasks must be completed. The necessary MOS guidance equations, software, and operational processes must be implemented in the NCEP operational jobstream. Products must be generated in GRIB2 format at the NCCS and transmitted to the Telecommunications Gateway. The products must be transmitted on the SBN to the local WFO's, decoded, and stored as netCDF files. The MOS variables in these files must be displayable in the d-2-d volume browser and must be available to the Grid Forecast Editor (GFE) for use as a possible method of initializing the local office grids. The local forecaster must have been trained in the use and value of the guidance grids and must have access to the appropriate tools required to manipulate the grids. An archive of the guidance grids must be established, and regular verification of the grids must be done. The MOS developers will need to work regularly on improving the quality of the grids. Finally, the process to add grids or new variables to the AWIPS datastream must be flexible enough that major code modifications are not required at the local WFO's.

5.b Roles and Responsibilities

Members of the Statistical Modeling Branch of MDL/OST (W/OST22) are responsible for deploying the operational equations, control files, software, and processes required to make the gridded MOS products on the NCCS. NCEP's NCO is responsible for implementing and maintaining the gridded MOS guidance in operations. The OCIO is responsible for assigning WMO headers for the products, adding those headers to the switching directory, and monitoring the daily transmission of the guidance products. Members of SEC/OST are responsible for establishing the processes and configuration files on AWIPS that are required to decode and database the guidance products. SEC is also responsible for updating the AWIPS GRIB2 decoder. The Training Branch of OCWWS will be responsible for providing training to the field.

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5.c Work and Budget Breakdown

Tasks include:

Implementing into the NCCS operational jobstream the MOS equations and processes required to create the gridded guidance

Creating the processes at the NCCS to transmit the MOS grids to the Telecommunications Gateway

Entering all WMO headers in the appropriate database at the Telecommunications Gateway

Modifying processes at the local WFO's so that the MOS grids are ingested, decoded, and stored in netCDF files

Modifying d-2-d and the volume browser so that the MOS grids are treated as another source of model data

Modifying processes, software, and tools so that the forecasters can interact with the MOS grids within GFE

Preparing a training module or teleconference presentation about the MOS grids

Preparing an objective and subjective evaluation of the quality and usefulness of the grids

5.d Acquisition Strategy

Budget resources are obtained via the normal NOAA budgeting process. The Statistical Modeling Branch is funded through the NOAA Weather and Water Goal Team, Environmental Modeling Program. The contractor employee is hired through the NWS task order contract with RSIS. Resources required for NCO, SEC, OCWWS, and the Regions will need to be determined and allocated according to organizational priorities.

5.e Performance Measures and Success Criteria

To be determined

5.f Schedules and Milestones

July 2005: Submit Request for Change to obtain first group of WMO product headers

January 2006: Produce grids for max/min temperature, temperature, dewpoint, relative humidity, wind speed, wind direction, thunderstorm probability, precipitation probability, and snowfall amount
March 2006: Submit Request for Change to obtain second group of WMO product headers
June 2006: Expand grids for the first group of elements to the CONUS
September 2006: Produce grids for precipitation type, precipitation amount, clouds, and wind gusts over the CONUS
October 2006: Submit Request for Change to obtain WMO product headers for Alaska gridded MOS products

5.g Assumptions and Constraints

All of this work is predicated upon adequate staff and computer resources being made available to the participating organizations. Lack of resources or a ban on changes being made to systems at the NCCS, the Telecommunications Gateway (TG), or the local AWIPS platforms will cause significant delays.

5.h Risk Assessment and Mitigation

The probability is quite high that these milestones will not be met because of computer problems, such as a lack of resoures at the NCCS or at the TG, which are outside the control of the participants. Communication among the people responsible for the completion of the work and discussions with the forecaster community will, at least, inform the stakeholders about potential delays.

APPENDIX A

Table A.1. Projections for which GFS-based MOS maximum (max) and minimum (min) temperature gridded products are issued. As noted in the table, guidance is available from either the 0000 or 1200 UTC cycles only. Note that the projections for the max and min temperature are only approximations, and denote daytime and nighttime valid periods, respectively.

Type															
	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192
Max	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z
Min	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z	00Z	12Z

Table A.2. Projections for which GFS-based MOS temperature, dew point, relative humidity, wind direction, wind speed, wind gust, sky cover and precipitation type gridded products are issued. Guidance is available from both the 0000 and 1200 UTC cycles. Projections refer to hours after 0000 or 1200 UTC.

Type	**Forecast Projections**
Temperature	Every 3 h from 6 to 192 hours
Dew Point	Every 3 h from 6 to 192 hours
Relative humidity	Every 3 h from 6 to 192 hours
Wind direction	Every 3 h from 6 to 192 hours
Wind speed	Every 3 h from 6 to 192 hours
Wind gusts	Every 3 h from 6 to 192 hours
Sky cover	Every 3 h from 6 to 192 hours
Precipitation type	Every 3 h from 6 to 192 hours

Table A.3. Projections for which GFS-based MOS probability of precipitation and probability of thunderstorms gridded products are issued. Guidance is available from both the 0000 and 1200 UTC cycles. Projections refer to the hour after 0000 or 1200 UTC that the period ends.

Type	**Forecast Projections**
Probability of precipitation – 6 h period	Every 6 h from 12 to 192 hours
Probability of precipitation – 12 h period	Every 6 h from 18 to 192 hours
Probability of thunderstorms – 6 h period	Every 6 h from 12 to 192 hours
Probability of thunderstorms – 12 h period	Every 6 h from 18 to 192 hours

Table A.4. Projections for which GFS-based MOS quantitative precipitation and snowfall amount gridded products are issued. Guidance is available from both the 0000 and 1200 UTC cycles. Projections refer to the hour after 0000 or 1200 UTC that the period ends.

Type	**Forecast Projections**
Quantitative precipitation – 6 h period	Every 6 h from 12 to 156 hours
Quantitative precipitation – 12 h period	Every 6 h from 18 to 156 hours
Snowfall amount – 24 h period	Every 12 h from 36 to 132 hours

Appendix B - WMO Headings for Gridded MOS Products

WMO headings have the format of $T_1T_2A_1A_2ii$ CCCC

1. The CCCC for all gridded MOS product WMO headings is **KWBQ**.

2. The T_1 for all gridded MOS products based on the global model is **L**.

3. The T_2 represents the weather element type designator. The following values are used for a T_1 = **L**. When feasible, these values match those used for the NDFD WMO headers.
Values for T_2 are:
A = sky cover
B = wind direction at sensor height (nominally, 10 m)
C = wind speed at sensor height (nominally, 10 m)
D = probability of precipitation (12 h)
E = temperature at sensor height (nominally, 2 m)
F = dewpoint temperature at sensor height (nominally, 2 m)
G = daytime maximum temperature at sensor height (nominally, 2 m)
H = nighttime minimum temperature at sensor height (nominally, 2 m)
I = quantitative precipitation (6 h)
J = thunderstorms (6 h)
K = severe weather (6 h)
L = precipitation type
M = precipitation characteristics
N = precipitation occurrence
O = obstruction to vision
P = visibility
Q = ceiling height
R = relative humidity
S = snowfall amount (24 h)
T = apparent temperature
U = probability of precipitation (6 h)
V = quantitative precipitation (12 h)
W = wind gusts
X = thunderstorms (12 h)
Y = unassigned
Z = unassigned

4. The A_1 designates the geographical area. The following designators follow the conventions established in the NDFD WMO headers.
A = Puerto Rico
R = Alaska
S = Hawaii
T = Guam
U = CONUS

5. The A_2 and ii follow the convention established in the NDFD. These three characters together represent the day and hour (UTC) for which the product is valid. The following convention for A_2 and ii is used for the gridded MOS products:
A = Day 0; ii = hour (0-23)
B = Day 1; ii = hour (0-23)

C = Day 2; ii = hour (0-23)
D = Day 3; ii = hour (0-23)
E = Day 4; ii = hour (0-23)
F = Day 5; ii = hour (0-23)
G = Day 6; ii = hour (0-23)
H = Day 7; ii = hour (0-23)
I = Day 8; ii = hour (0-23)
J = Day 9; ii = hour (0-23)

Table B.1. WMO headers for gridded MOS products. The headers shown are for the CONUS only. The complete headers shown in Tables B.2 are given for those elements to be transmitted in the first two releases of the gridded MOS products. Information for the other headers will be added, as available and needed.

Element	**Header**	**No. of grids per cycle**	**First/Last Proj./Time Increment (hr)**	**Bytes per grid/cycle**
Sky Cover	$LAUA_2ii$	63	6/192/3	100K/6.3M
Wind Direction	$LBUA_2ii$	63	6/192/3	225K/14.2M
Wind Speed	$LCUA_2ii$	63	6/192/3	125K/7.9M
PoP (12h)	$LDUA_2ii$	30	18/192/6	100K/3.0M
Temperature	$LEUA_2ii$	63	6/192/3	250K/15.8M
Dew Point	$LFUA_2ii$	63	6/192/3	250K/15.8M
Daytime Max	$LGUA_2ii$	8(00Z) 7(12Z)	24/192/24 36/180/24	250K/2.0M 250K/1.7M
Nighttime Min	$LHUA_2ii$	7(00Z) 8(12Z)	36/180/24 24/192/24	250K/1.7M 250K/2.0M
Quantitative Pre-cip. (6h)	$LIUA_2ii$	25	12/156/6	100K/2.5M
Tstm. Prob. (6h)	$LJUA_2ii$	31	12/192/6	100K/3.1M
Svr. Wx. Prob. (6h)	$LKUA_2ii$	TBD	TBD	100K/TBD
Precip. Type	$LLUA_2ii$	63	6/192/3	100K/6.3M
Precip. Character.	$LMUA_2ii$	TBD	TBD	100K/TBD
Precip. Occurrence	$LNUA_2ii$	TBD	TBD	100K/TBD
Obs. Vision	$LOUA_2ii$	TBD	TBD	100K/TBD
Visibility	$LPUA_2ii$	TBD	TBD	100K/TBD
Ceiling Height	$LQUA_2ii$	TBD	TBD	100K/TBD
Relative Humidity	$LRUA_2ii$	63	6/192/3	100K/6.3M
Snowfall Amount (24h)	$LSUA_2ii$	9	36/132/12	100K/0.9M
Apparent Temp.	$LTUA_2ii$	TBD	TBD	250K/TBD
PoP (6h)	$LUUA_2ii$	31	12/192/6	100K/3.1M
Quantitative Pre-cip. (12h)	$LVUA_2ii$	24	18/156/6	100K/2.4M
Wind Gusts	$LWUA_2ii$	63	6/192/3	150K/9.4M
Tstm. Prob. (12h)	$LXUA_2ii$	30	18/192/6	100K/3.0M

Table B.2. WMO headers for gridded MOS products expected to be transmitted initially on the SBN in 2006.

Element	Header Category	Product Headers
Sky Cover	$LAUA_2ii$	LAUA18 LAUA21 LAUB00 LAUB03 LAUB06 LAUB09 LAUB12 LAUB15 LAUB18 LAUB21 LAUC00 LAUC03 LAUC06 LAUC09 LAUC12 LAUC15 LAUC18 LAUC21 LAUD00 LAUD03 LAUD06 LAUD09 LAUD12 LAUD15 LAUD18 LAUD21 LAUE00 LAUE03 LAUE06 LAUE09 LAUE12 LAUE15 LAUE18 LAUE21 LAUF00 LAUF03 LAUF06 LAUF09 LAUF12 LAUF15 LAUF18 LAUF21 LAUG00 LAUG03 LAUG06 LAUG09 LAUG12 LAUG15 LAUG18 LAUG21 LAUH00 LAUH03 LAUH06 LAUH09 LAUH12 LAUH15 LAUH18 LAUH21 LAUI00 LAUI03 LAUI06 LAUI09 LAUI12 LAUI15 LAUI18 LAUI21 LAUJ00
Wind Direc- tion	$LBUA_2ii$	LBUA18 LBUA21 LBUB00 LBUB03 LBUB06 LBUB09 LBUB12 LBUB15 LBUB18 LBUB21 LBUC00 LBUC03 LBUC06 LBUC09 LBUC12 LBUC15 LBUC18 LBUC21 LBUD00 LBUD03 LBUD06 LBUD09 LBUD12 LBUD15 LBUD18 LBUD21 LBUE00 LBUE03 LBUE06 LBUE09 LBUE12 LBUE15 LBUE18 LBUE21 LBUF00 LBUF03 LBUF06 LBUF09 LBUF12 LBUF15 LBUF18 LBUF21 LBUG00 LBUG03 LBUG06 LBUG09 LBUG12 LBUG15 LBUG18 LBUG21 LBUH00 LBUH03 LBUH06 LBUH09 LBUH12 LBUH15 LBUH18 LBUH21 LBUI00 LBUI03 LBUI06 LBUI09 LBUI12 LBUI15 LBUI18 LBUI21 LBUJ00
Wind Speed	$LCUA_2ii$	LCUA18 LCUA21 LCUB00 LCUB03 LCUB06 LCUB09 LCUB12 LCUB15 LCUB18 LCUB21 LCUC00 LCUC03 LCUC06 LCUC09 LCUC12 LCUC15 LCUC18 LCUC21 LCUD00 LCUD03 LCUD06 LCUD09 LCUD12 LCUD15 LCUD18 LCUD21 LCUE00 LCUE03 LCUE06 LCUE09 LCUE12LCUE15 LCUE18 LCUE21 LCUF00 LCUF03 LCUF06 LCUF09 LCUF12 LCUF15 LCUF18 LCUF21

		LCUG00 LCUG03 LCUG06 LCUG09 LCUG12 LCUG15 LCUG18 LCUG21 LCUH00 LCUH03 LCUH06 LCUH09 LCUH12 LCUH15 LCUH18 LCUH21 LCUI00 LCUI03 LCUI06 LCUI09 LCUI12 LCUI15 LCUI18 LCUI21 LCUJ00
PoP (12 h)	LDUZ98	LDUB06 LDUB12 LDUB18 LDUC00 LDUC06 LDUC12 LDUC18 LDUD00 LDUD06 LDUD12 LDUD18 LDUE00 LDUE06 LDUE12 LDUE18 LDUF00 LDUF06 LDUF12 LDUF18 LDUG00 LDUG06 LDUG12 LDUG18 LDUH00 LDUH06 LDUH12 LDUH18 LDUI00 LDUI06 LDUI12 LDUI18 LDUJ00
Temperature	LEUZ98	LEUA18 LEUA21 LEUB00 LEUB03 LEUB06 LEUB09 LEUB12 LEUB15 LEUB18 LEUB21 LEUC00 LEUC03 LEUC06 LEUC09 LEUC12 LEUC15 LEUC18 LEUC21 LEUD00 LEUD03 LEUD06 LEUD09 LEUD12 LEUD15 LEUD18 LEUD21 LEUE00 LEUE03 LEUE06 LEUE09 LEUE12 LEUE15 LEUE18 LEUE21 LEUF00 LEUF03 LEUF06 LEUF09 LEUF12 LEUF15 LEUF18 LEUF21 LEUG00 LEUG03 LEUG06 LEUG09 LEUG12 LEUG15 LEUG18 LEUG21 LEUH00 LEUH03 LEUH06 LEUH09 LEUH12 LEUH15 LEUH18 LEUH21 LEUI00 LEUI03 LEUI06 LEUI09 LEUI12 LEUI15 LEUI18 LEUI21 LEUJ00
Dew Point	LFUZ98	LFUA18 LFUA21 LFUB00 LFUB03 LFUB06 LFUB09 LFUB12 LFUB15 LFUB18 LFUB21 LFUC00 LFUC03 LFUC06 LFUC09 LFUC12 LFUC15 LFUC18 LFUC21 LFUD00 LFUD03 LFUD06 LFUD09 LFUD12 LFUD15 LFUD18 LFUD21 LFUE00 LFUE03 LFUE06 LFUE09 LFUE12 LFUE15 LFUE18 LFUE21 LFUF00 LFUF03 LFUF06 LFUF09 LFUF12 LFUF15 LFUF18 LFUF21 LFUG00 LFUG03 LFUG06 LFUG09 LFUG12 LFUG15 LFUG18 LFUG21 LFUH00 LFUH03 LFUH06 LFUH09 LFUH12 LFUH15 LFUH18 LFUH21 LFUI00 LFUI03 LFUI06 LFUI09 LFUI12 LFUI15 LFUI18 LFUI21

		LFUJ00
Daytime Max	LGUZ98	LGUC00 LGUD00 LGUE00 LGUF00 LGUG00 LGUH00 LGUI00 LGUJ00
Nighttime Min	LHUZ98	LHUB12 LHUC12 LHUD12 LHUE12 LHUF12 LHUG12 LHUH12 LHUI12
Quantitative Precip. (6h)	LIUZ98	LIUB00 LIUB06 LIUB12 LIUB18 LIUC00 LIUC06 LIUC12 LIUC18 LIUD00 LIUD06 LIUD12 LIUD18 LIUE00 LIUE06 LIUE12 LIUE18 LIUF00 LIUF06 LIUF12 LIUF18 LIUG00 LIUG06 LIUG12 LIUG18 LIUH00 LIUH06 LIUH12
Tstm. Prob. (6h)	LJUZ98	LJUB00 LJUB06 LJUB12 LJUB18 LJUC00 LJUC06 LJUC12 LJUC18 LJUD00 LJUD06 LJUD12 LJUD18 LJUE00LJUE06 LJUE12 LJUE18 LJUF00 LJUF06 LJUF12 LJUF18 LJUG00 LJUG06 LJUG12 LJUG18 LJUH00 LJUH06 LJUH12 LJUH18 LJUI00 LJUI06 LJUI12 LJUI18 LJUJ00
Precip. Type	LLUZ98	LLUA18 LLUA21 LLUB00 LLUB03 LLUB06 LLUB09 LLUB12 LLUB15 LLUB18 LLUB21 LLUC00 LLUC03 LLUC06 LLUC09 LLUC12 LLUC15 LLUC18 LLUC21 LLUD00 LLUD03 LLUD06 LLUD09 LLUD12 LLUD15 LLUD18 LLUD21 LLUE00 LLUE03 LLUE06 LLUE09 LLUE12 LLUE15 LLUE18 LLUE21 LLUF00 LLUF03 LLUF06 LLUF09 LLUF12 LLUF15 LLUF18 LLUF21 LLUG00 LLUG03 LLUG06 LLUG09 LLUG12 LLUG15 LLUG18 LLUG21 LLUH00 LLUH03 LLUH06 LLUH09 LLUH12 LLUH15 LLUH18 LLUH21 LLUI00 LLUI03 LLUI06 LLUI09 LLUI12 LLUI15 LLUI18 LLUI21 LLUJ00
Relative Hu-midity	LRUZ98	LRUA18 LRUA21 LRUB00 LRUB03 LRUB06 LRUB09 LRUB12 LRUB15 LRUB18 LRUB21 LRUC00 LRUC03 LRUC06 LRUC09 LRUC12 LRUC15 LRUC18 LRUC21 LRUD00 LRUD03 LRUD06 LRUD09 LRUD12 LRUD15 LRUD18 LRUD21 LRUE00 LRUE03 LRUE06 LRUE09 LRUE12 LRUE15 LRUE18 LRUE21 LRUF00 LRUF03 LRUF06 LRUF09 LRUF12 LRUF15 LRUF18 LRUF21

		LRUG00 LRUG03 LRUG06 LRUG09 LRUG12 LRUG15 LRUG18 LRUG21 LRUH00 LRUH03 LRUH06 LRUH09 LRUH12 LRUH15 LRUH18 LRUH21 LRUI00 LRUI03 LRUI06 LRUI09 LRUI12 LRUI15 LRUI18 LRUI21 LRUJ00
Snowfall Amount (24h)	LSUZ98	LSUC00 LSUC12 LSUD00 LSUD12 LSUE00 LSUE12 LSUF00 LSUF12 LSUG00 LSUG12
PoP (6h)	LUUZ98	LUUB00 LUUB06 LUUB12 LUUB18 LUUC00 LUUC06 LUUC12 LUUC18 LUUD00 LUUD06 LUUD12 LUUD18 LUUE00 LUUE06 LUUE12 LUUE18 LUUF00 LUUF06 LUUF12 LUUF18 LUUG00 LUUG06 LUUG12 LUUG18 LUUH00 LUUH06 LUUH12 LUUH18 LUUI00 LUUI06 LUUI12 LUUI18 LUUJ00
Quantitative Precip. (12h)	LVUZ98	LVUB06 LVUB12 LVUB18 LVUC00 LVUC06 LVUC12 LVUC18 LVUD00 LVUD06 LVUD12 LVUD18 LVUE00 LVUE06 LVUE12 LVUE18 LVUF00 LVUF06 LVUF12 LVUF18 LVUG00 LVUG06 LVUG12 LVUG18 LVUH00 LVUH06 LVUH12
Wind Gusts	LWUZ98	LWUA18 LWUA21 LWUB00 LWUB03 LWUB06 LWUB09 LWUB12 LWUB15 LWUB18 LWUB21 LWUC00 LWUC03 LWUC06 LWUC09 LWUC12 LWUC15 LWUC18 LWUC21 LWUD00 LWUD03 LWUD06 LWUD09 LWUD12 LWUD15 LWUD18 LWUD21 LWUE00 LWUE03 LWUE06 LWUE09 LWUE12 LWUE15 LWUE18 LWUE21 LWUF00 LWUF03 LWUF06 LWUF09 LWUF12 LWUF15 LWUF18 LWUF21 LWUG00 LWUG03 LWUG06 LWUG09 LWUG12 LWUG15 LWUG18 LWUG21 LWUH00 LWUH03 LWUH06 LWUH09 LWUH12 LWUH15 LWUH18 LWUH21 LWUI00 LWUI03 LWUI06 LWUI09 LWUI12 LWUI15 LWUI18 LWUI21 LWUJ00
Tstm. Prob. (12h)	LXUZ98	LXUB06 LXUB12 LXUB18 LXUC00 LXUC06 LXUC12 LXUC18 LXUD00 LXUD06 LXUD12 LXUD18 LXUE00 LXUE06 LXUE12 LXUE18 LXUF00 LXUF06 LXUF12 LXUF18 LXUG00 LXUG06 LXUG12 LXUG18 LXUH00 LXUH06 LXUH12 LXUH18

		LXUI00 LXUI06 LXUI12 LXUI18 LXUJ00

Appendix C – Telecommunications Gateway File Server Structure for Gridded MOS Products

Note all products are in grib2 format and cover the CONUS on the NDFD grid; at this time, only the western third of the grid is populated with guidance; the remainder of the grid contains missing values.

Guidance products are aggregated for the same weather element and geographical area. The aggregation is stored in individual files on the ftp server where a single file contains individual products for groupings of forecast periods. Groupings of forecast periods are designated as days 1 – 3 and days 4 – 7. For user convenience and for eventual consistency with NDFD, the products for Day 4, hour 00, are included in the days 1 – 3 file. The remainder of the MOS guidance beyond Day 4, hour 00 is included in the days 4 – 7 file.

NDGD tgftp file structure
root: ftp://tgftp.nws.noaa.gov/SL.us008001/

status of data (experimental): ST.expr/

data format (grib2): DF.gr2/

data category (ndgd): DC.ndgd/

guidance type (gfs-based MOS): GT.mosgfs/

area of data (CONUS): AR.conus/

valid period VP.d001-003/ – for days 1 to 3
VP.d004-007/ – for days 4 to 7

ds.sssss (file name or data subcategory):
ds.maxt.bin – max temperature
ds.mint.bin – min temperature
ds.temp.bin – 2-m temperature
ds.td.bin – 2-m dewpoint

Thus, as an example, the complete file name (minus, the ftp server name) containing the gridded MOS max temperatures for days 4 through 7 looks like:

SL.us008001/ST.expr/DF.gr2/DC.ndgd/GT.mosgfs/AR.conus/VP.d004-007/ds.maxt.bin

Table C.1. Groupings for gridded MOS products. The rest of the elements still need to be put in the table.

Gridded MOS Element	Valid Period (VP)	No. of grids per file(00/12Z)	Time increment/final projection	Size per grid
Temperature	d001-003 d004-007	23 - 27 36 – 40	3/84 3/192	250K
Dew Point	d001-003 d004-007	23 - 27 36 - 40	3/84 3/192	250K
Daytime Max	d001-003 d004-007	3 4 - 5	24/84 24/192	250K

Nighttime Min	d001-003 d004-007	3 4 - 5	24/84 24/192	250K